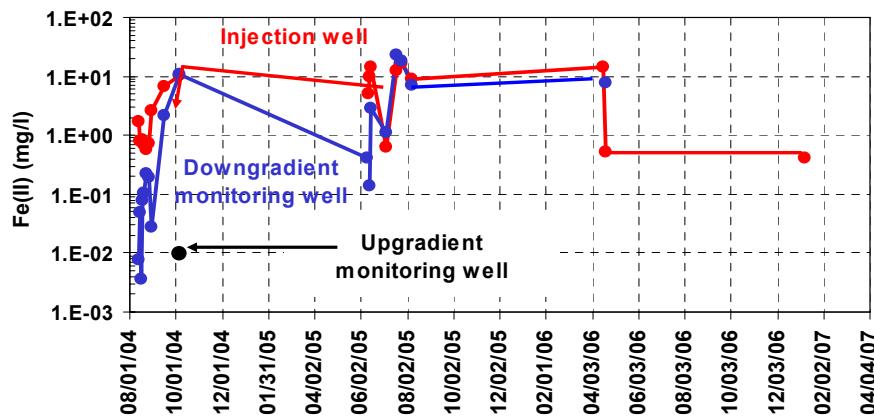


Statistical Analysis of the Results of Pumping/Tracer Tests and Geophysical Data

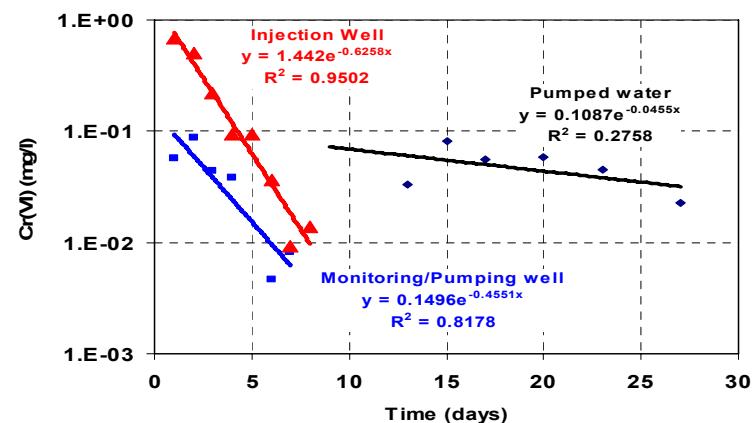
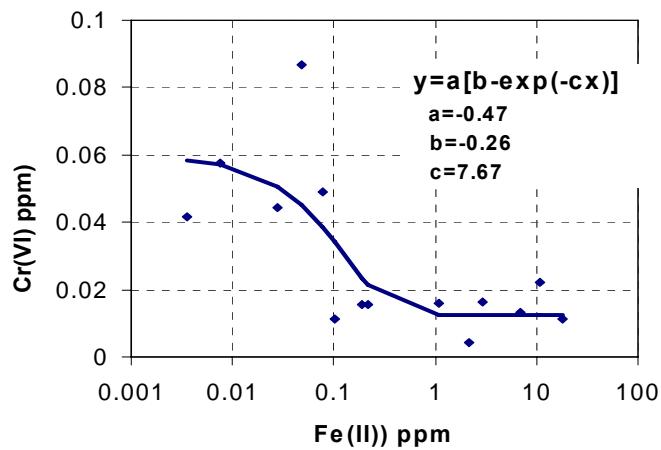
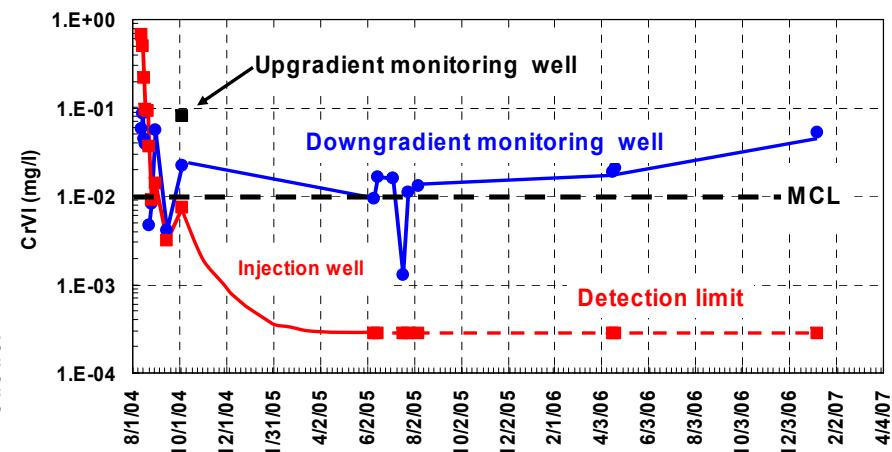
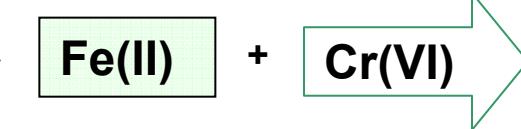
Boris Faybisenko
LBNL

July 31, 2007

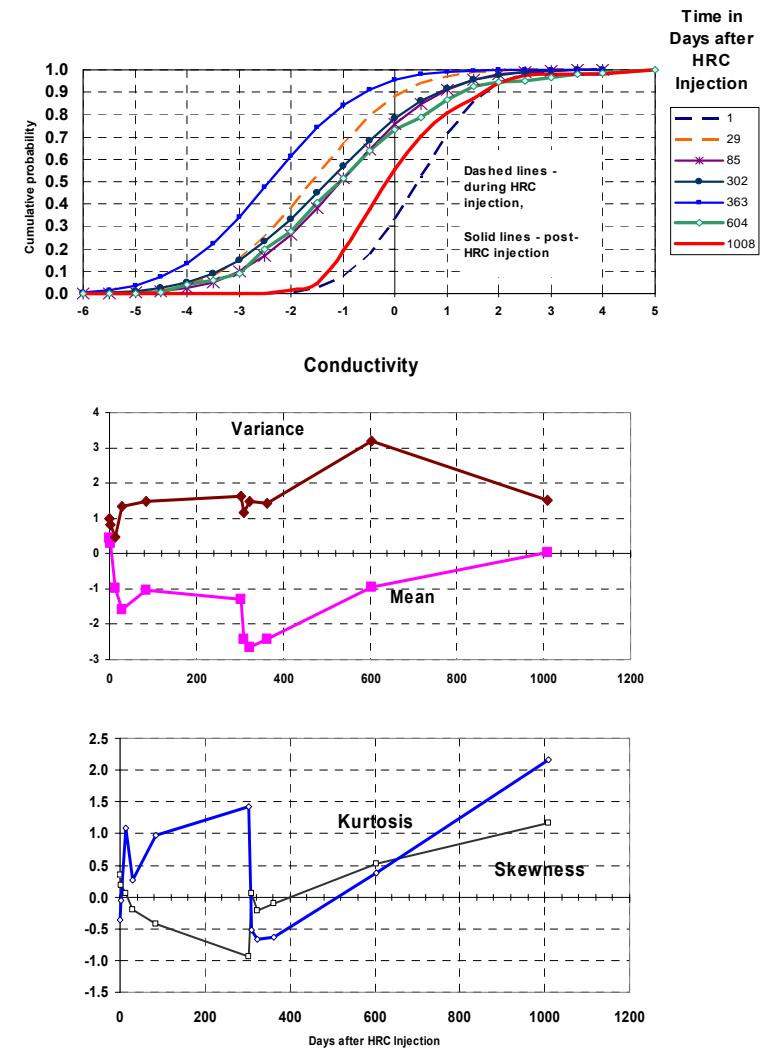
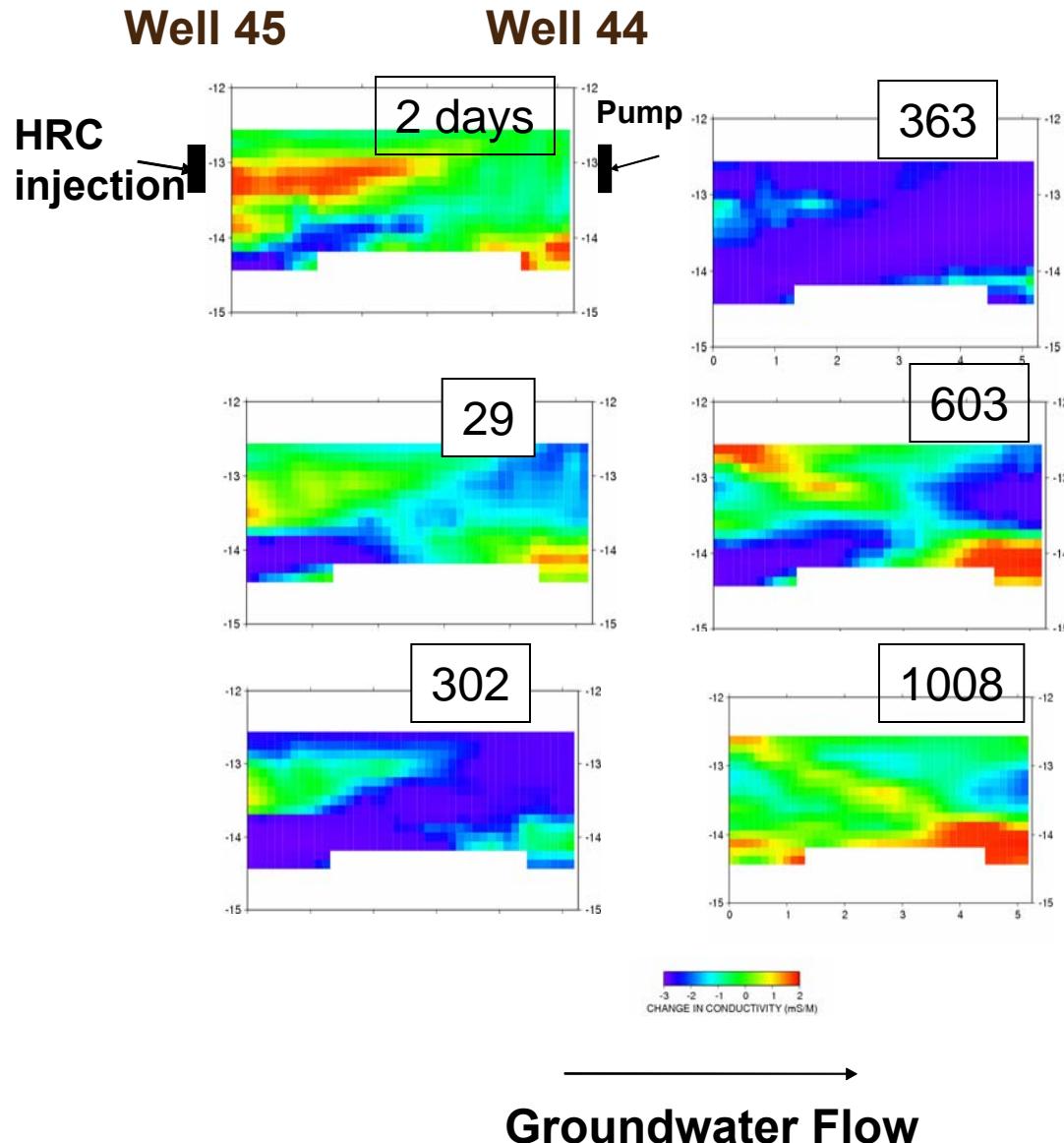
Fe (III) reduction



Cr(VI) Reduction



Post-HRC Injection Electrical Conductivity Difference Tomographs and Moments Analysis



Moments of a Distribution

- Variance

$$\frac{\sum (x - \bar{x})^2}{n - 1}$$

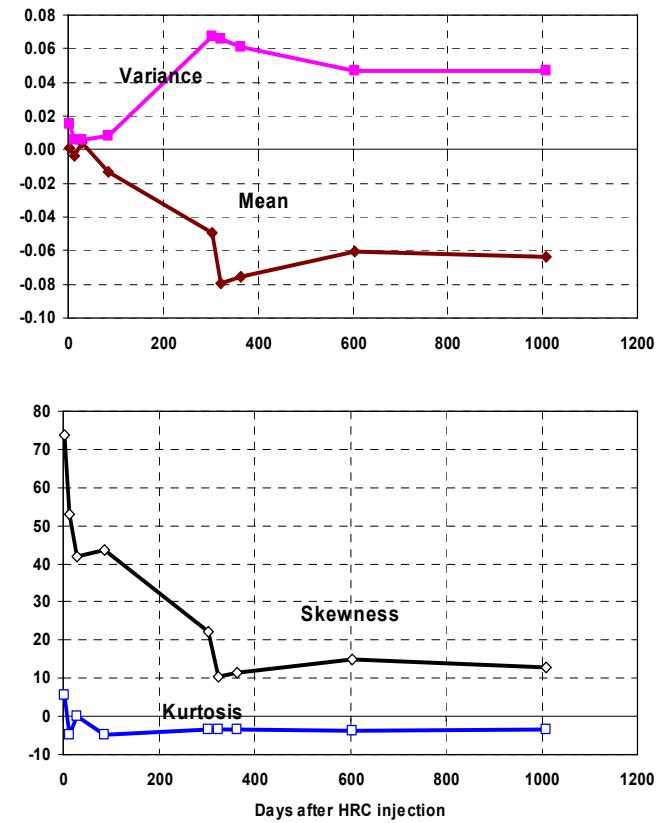
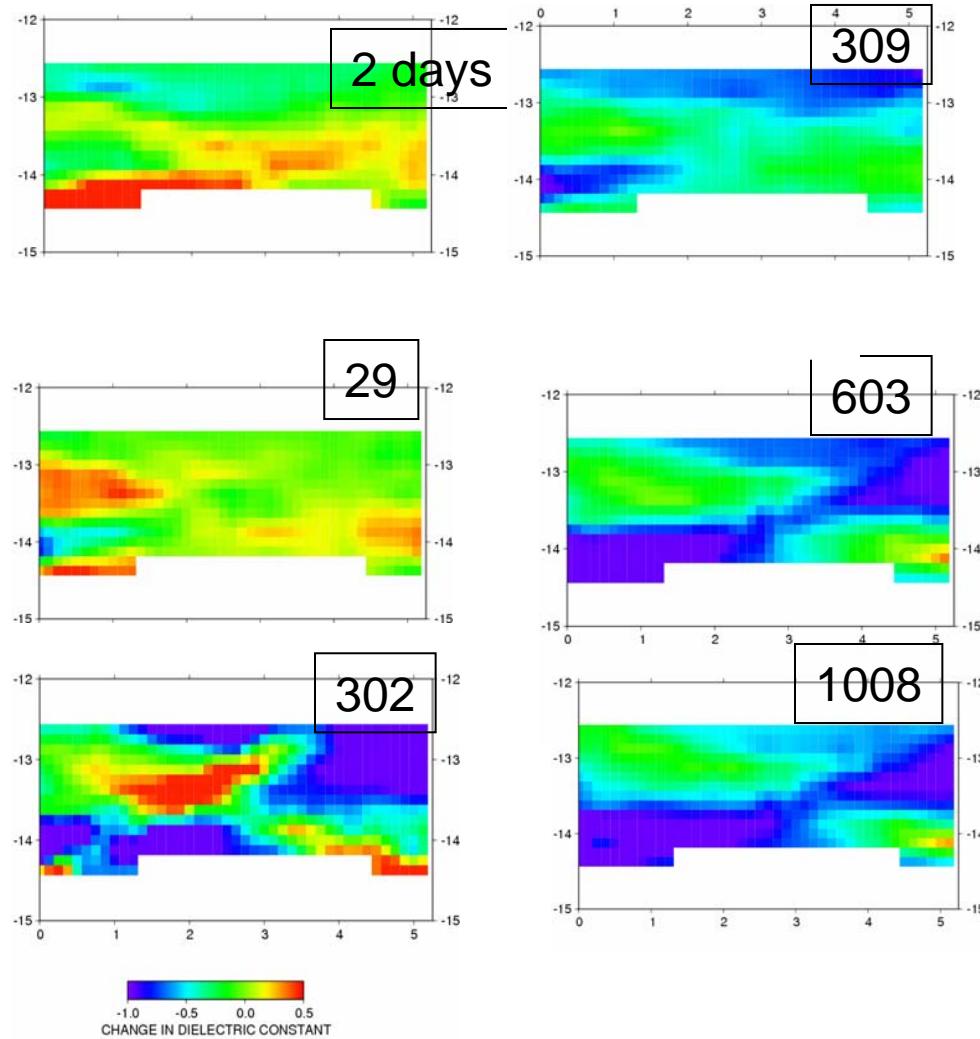
- Skewness -- the degree of asymmetry of a distribution around its mean
 - Positive skewness -- an asymmetric tail extending toward more positive values.
 - Negative skewness -- an asymmetric tail extending toward more negative values.

$$\frac{n}{(n-1)(n-2)} \sum_{j=1}^N \left(\frac{x_j - \bar{x}}{s} \right)^3$$

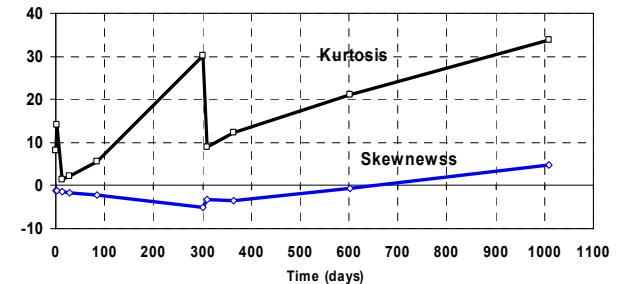
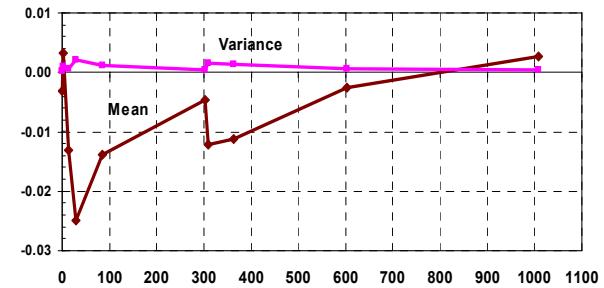
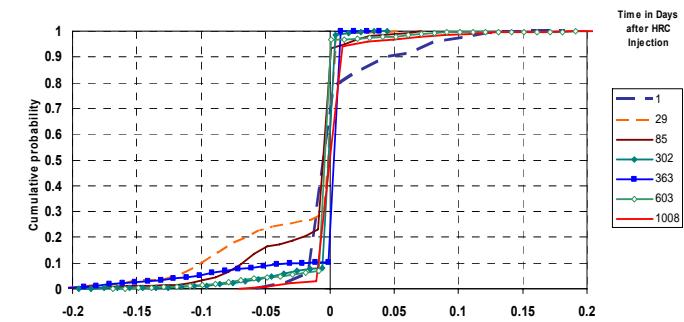
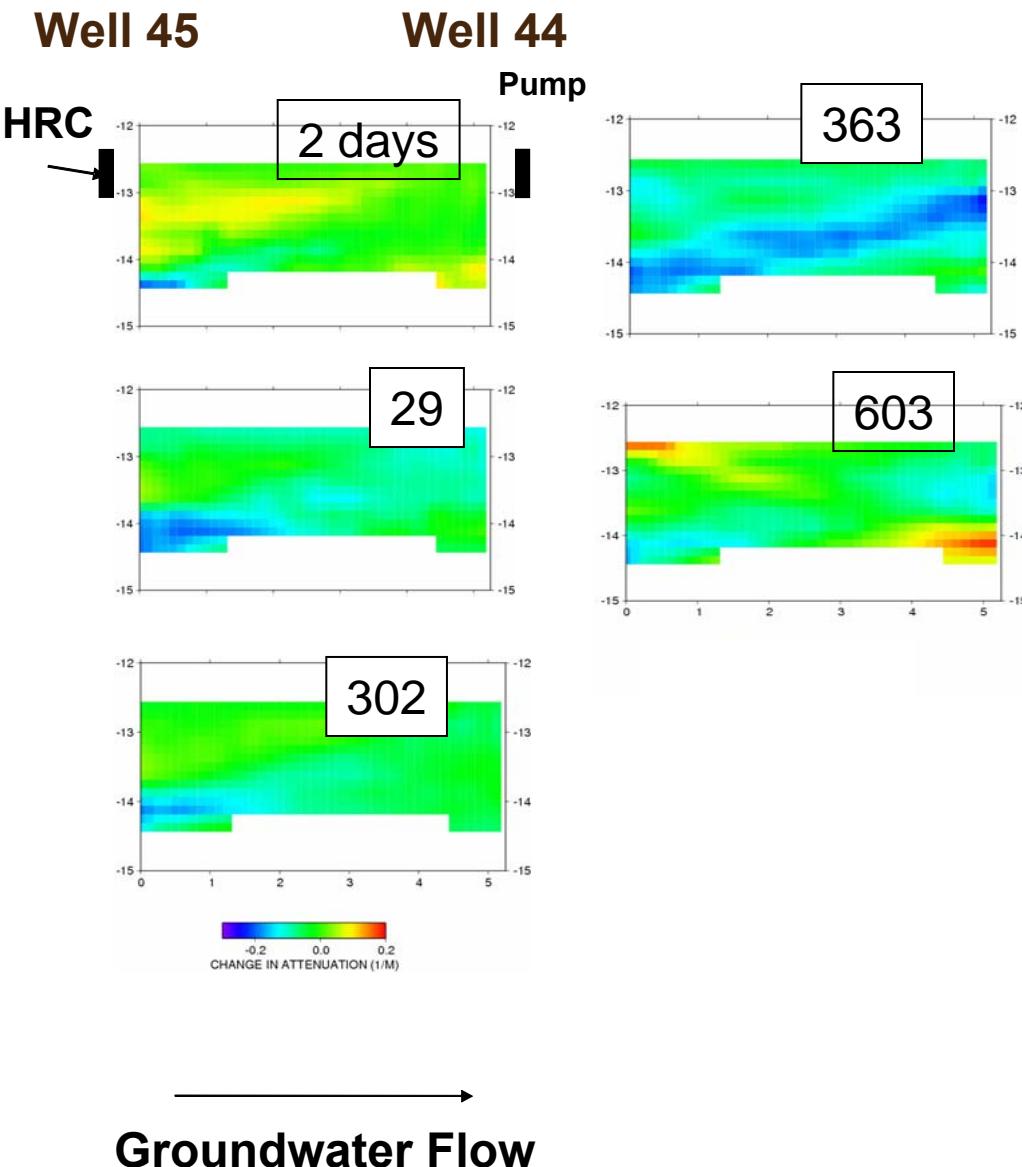
- Kurtosis -- the relative peakedness or flatness of a distribution compared with the normal distribution.
 - Positive kurtosis -- a relatively peaked distribution.
 - Negative kurtosis -- a relatively flat distribution.

$$\frac{n(n+1)}{(n-1)(n-2)} (n-3) \sum \left(\frac{x_j - \bar{x}}{s} \right)^4 - \frac{3(n-1)^2}{(n-2)(n-3)}$$

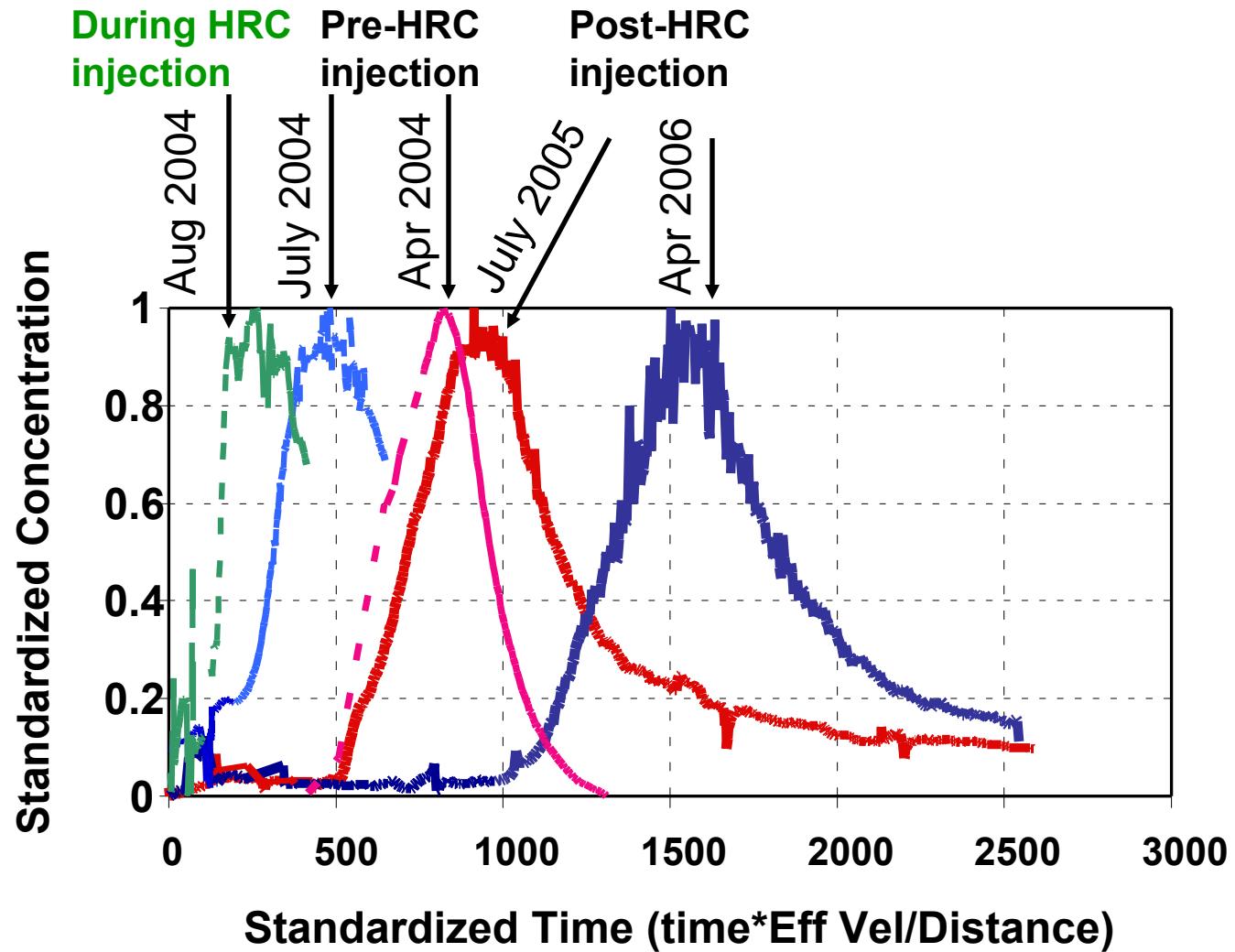
Dielectric Difference Tomographs and Moments Analysis



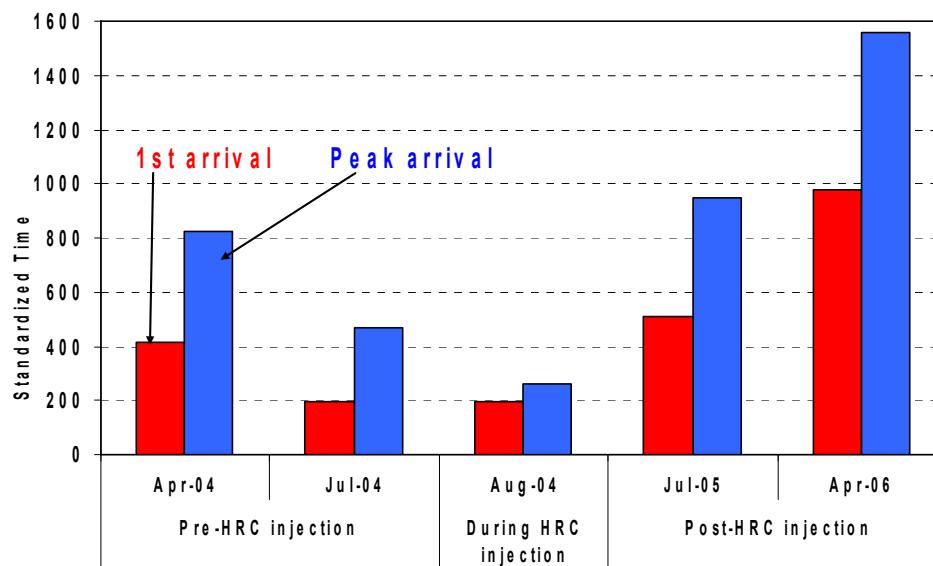
Post-HRC Injection Attenuation Difference Tomographs and Moments Analysis



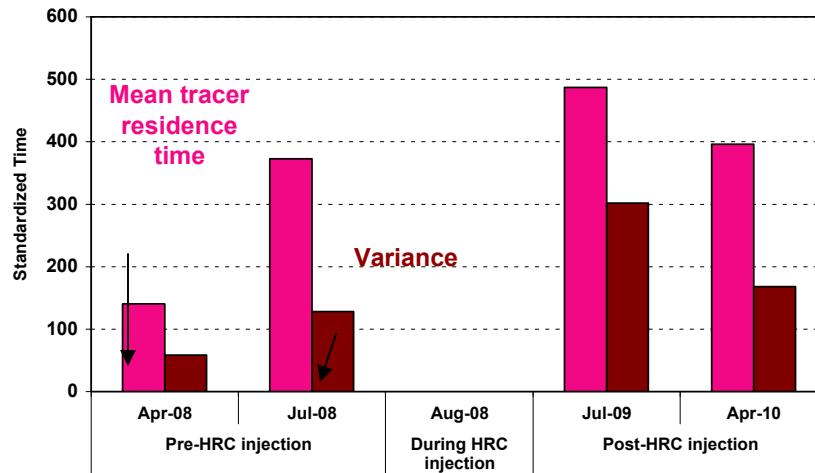
Increase in the Br Travel Time after the HRC Injection



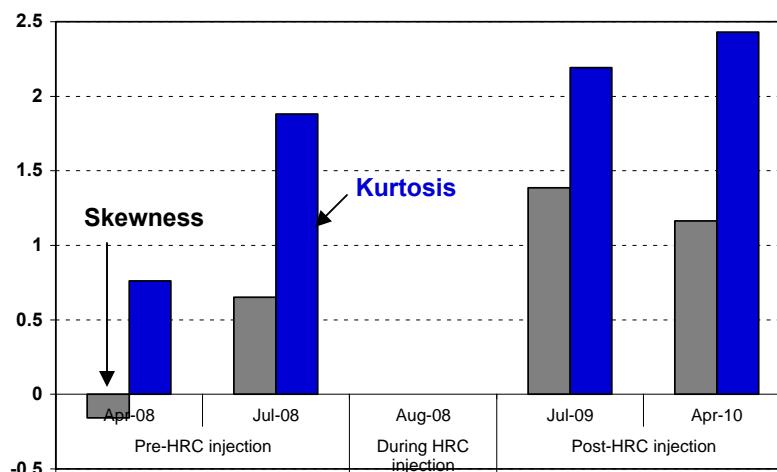
Water Travel Time between Injection and Pumping Wells



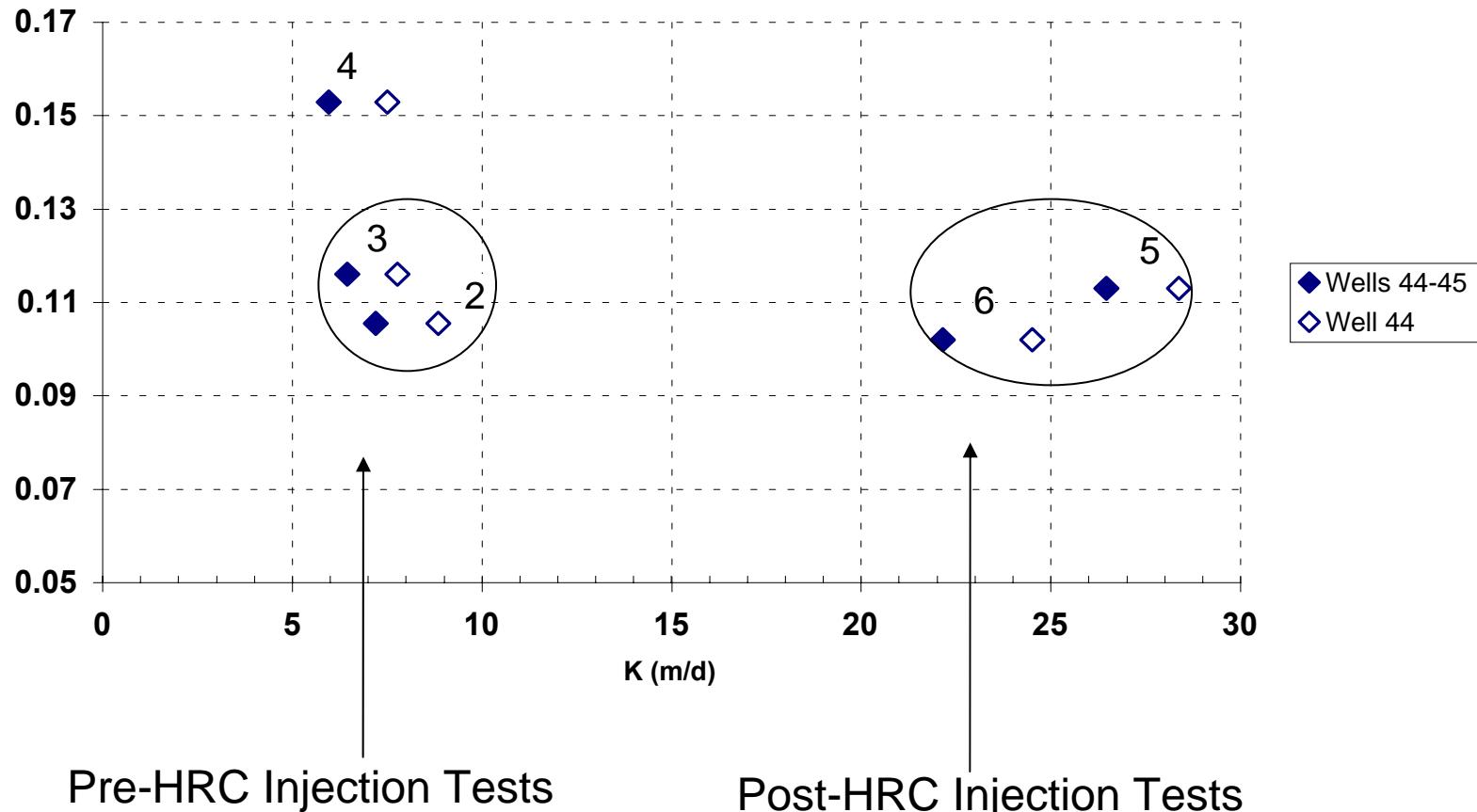
Pre- and Post HRC Injection Br BTCs Moments



- Multi-rate mobile-immobile biogeochemical processes:
 - advective transport and hydrodynamic dispersion process along preferential flow zones
 - molecular diffusion and mechanical mixing between mobile and immobile flow zones
- Direct comparison of geophysical and water-chemistry data is not straightforward.



Apparent K_{sat} and Effective Porosity from Pumping Tests



$$Q = K \uparrow \text{grad}H F \downarrow$$

K_{sat} from Pumping and Tracer Tests

- Pumping tests generate higher K_{sat} values, caused by preferential flow processes in the mobile domain
- Tracer tests generate lower K_{sat} values, because of mixing and retardation, as solute moves into and out of the immobile domain

Biogeochemical Processes Affecting Flow, Transport, and Geophysical Properties

- **Gas formation:** denitrification and CO₂
- **Particular matter**
 - Calcite precipitation
 - Cr(III) complexes precipitation
 - Fe(III) reduction
- **Microbial complexes and biofilms**
- **Aqueous solutions**
 - Cr(VI) reduction
 - Fe(II) formation

Gaps and Future Research

- What causes changes in sediments' hydraulic properties?
 - Conduct a new tracer/pumping test using monitoring in new boreholes
 - Numerical modeling of tracer and pumping tests using multi-rate mobile/immobile flow and transport models
 - Sensitivity analysis of hydrogeological parameters to optimize the heterogeneity (mobile-immobile domains) model
- What is the contribution of different biogeochemical processes affecting Cr(VI) bioimmobilization?
 - A series of lab-scale column experiments